

Marine gastropods of Accra Beach, Barbados, North Atlantic Ocean

Gastrópodes marinhos da Praia de Accra, Ilha de Barbados, Oceano Atlântico Norte

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Abstract

The widespread occurrence of marine gastropods in coastal regions is a straightforward evidence of successful adaptation to different environments. In the Caribbean Sea, as one of Conservation International's biodiversity hotspots, little is known about the gastropod fauna, especially in the Eastern Caribbean. The present study contributed to bridge this gap by studying the biodiversity of gastropods from Accra Beach, Barbados. Throughout random collections in September 2015, we collected

321 gastropods, comprising eight species, distributed in three families (Neritidae: *Nerita tessellata*, *N. fulgurans*, *N. versicolor* and *N. peloronta*; Littorinidae: *Echinolittorina ziczac*, *E. angustior* and *E. tuberculata*; and Muricidae: *Plicopurpura patula*). Nerites were more abundant and diverse, highlighting *N. tessellata*, representing 66% of the sampled gastropods. This paper also reports the first record of *N. fulgurans* and *E. angustior* for the island of Barbados.

Resumo

A ampla ocorrência de gastrópodes marinhos em regiões costeiras é uma evidência direta da adaptação bem-sucedida a diferentes ambientes. No Mar do Caribe, considerado um dos *hotspots* de biodiversidade da Conservation International, pouco se conhece sobre diversidade de gastrópodes, especialmente no Caribe Oriental. O presente trabalho tem como objetivo contribuir ao conhecimento da biodiversidade de gastrópodes ocorrentes na praia de Accra, através de coletas em setembro de 2015. No total encontraram-se 321 gastrópodes marinhos, pertencentes a oito espécies distribuídas em três famílias (Neritidae: *Nerita tessellata*, *N. fulgurans*, *N. versicolor* e *N. peloronta*; Littorinidae: *Echinolittorina ziczac*, *E. angustior* e *E. tuberculata*; e Muricidae: *Plicopurpura patula*). Os nerítídeos apresentaram-se mais abundantes e diversos, destacando *N. tessellata*, representando 66% da fauna de gastrópodes encontrados. Este artigo também relata o primeiro registro de *N. fulgurans* e *E. angustior* para a Ilha de Barbados.

Keywords

Caribbean island, *Echinolittorina angustior*, Gastropoda, *Nerita fulgurans*, new records

Palavras-chave

Echinolittorina angustior, Ilhas caribenhas, Gastropoda, *Nerita fulgurans*, novo registros

Mollusks are common invertebrate organisms found abundantly in the most diverse aquatic systems (marine, estuaries and freshwater), which is mainly related to their high diversity. This phylum is divided into seven classes, namely: Monoplacophora, Polyplacophora, Aplacophora, Gastropoda, Bivalvia, Scaphopoda and Cephalopoda (Ruppert and Barnes 1996; Brusca and Brusca 2007).

Gastropods are relevant in the food chain, serving as food for other animals, acting as intermediate hosts in the life cycle of pathogens, acting as environmental pests (e.g., bioinvasion), which generates economic losses. In addition, some species (e.g., *Helix aspersa* Muller, 1774) can be cultivated and marketed (Hickman et al. 2001; Barros et al. 2019).

The Caribbean Sea covers an area of about 2,754,000 km² and is characterized by a tropical half open sea, belonging to the Atlantic Ocean, bounded to the south of North America, east of the Central America and the north of South America (Diaz 1995). This region has a high marine biodiversity, distributed in many different environments, presenting numerous endemic mollusk species (Diaz 1995; Diaz-Ferguson et al. 2011).

Several studies address the diversity of mollusks of the islands bathed by the Caribbean Sea. Studies include records of gastropods of the families Neritidae (Russel 1941; Flores 1964; Chislett 1970; Prado 1998; Chagas et al. 2016) and Littorinidae (Reid 2009), as well as Opisthobranchia (Marcus and Hughes 1974) and

Heterobranchia (Goodheart et al. 2016). In addition, there is information about the invasion of Caribbean species in other regions (Lima et al. 2011) and studies about morphology, distribution, habitat data and preservation information (Diaz and Puyana 1994; Abbott and Morris 1995; Rosenberg et al. 2009; Wittmer 2012).

Based on the above, the present work aims to contribute to the knowledge of the diversity of gastropods occurring on the beach of Accra, located south of Barbados, the Caribbean Sea, the North Atlantic, presenting new species records for the region.

The island of Barbados, bathed by the Atlantic Ocean, is located to the east of the Caribbean islands, south of Saint Lucia, east of Saint Vincent and the Grenadines, and north of Trinidad and Tobago. It has a 97 km long coastline, with an area of 431 m² (Meditz and Hanratty 1987). According to the authors, the island has a mild subtropical climate, with well-defined seasons, and a dry period from December-June and rainy from July to November.

The collection of organisms took place on the beach of Accra (13°4'24.85"N, 59°35'23.69"W), situated to the south of the island of Barbados (Fig. 1), during low tide in September 2015. The sampling area is characterized by the predominance of large rocks along the entire length of the beach. It is noteworthy that, being an area with a knowledge gap about the diversity of mollusks, the collection was limited to a single sampling and thus, subsidizing future periodic sampling.

An area of 100 m² was delimited by the extension of the supralittoral of the beach and the found gastropods were sampled. After sampling, the external morphometry (length, width, height, length of the shell opening and width of the shell opening) of the gastropods was performed in situ.

Some specimens were fixed in 70% alcohol for taxonomic identification and after the cleaning of the shells, according to Thomé et al. (2010), individuals of each species were deposited in the malacological collection of the Museum of Zoology of the Federal Rural University of Amazonia (MZUFRA). The identification of the gastropods followed specific literature for the Neritidae family (Reeve 1856; Flores 1964; Prado 1998; Reid 2007, 2009; Rios 2009).

The dataset of gastropod composition found on Accra beach (Chagas et al. 2019) is available on the digital platform PANGAEA – *Publishing Network for Geoscientific & Environmental Data* (<https://www.pangaea.de/>).

A total of 321 marine gastropods were found, belonging to eight species distributed in three families. The family Neritidae Rafinesque, 1815 was more abundant and diverse (n = 314), with 4 species, followed by the families Littorinidae Children, 1834 (n = 5) and Muricidae Rafinesque, 1815 (n = 2), with 3 and 2 species, respectively.

The neritid *Nerita tessellata* Gmelin, 1791 accounted for 66% of all recorded gastropods, being much more abundant in the sampling than the other species of the same family: *Nerita fulgurans* Gmelin, 1791 (20.6%), *Nerita versicolor* Gmelin, 1791 (6.2%) and *Nerita peloronta* Linnaeus, 1758 (5%). Among the littorinids, *Echinolittorina ziczac* (Gmelin, 1791) represented 0.9% of the recorded individuals and *Echinolittorina angustior* (Mörch, 1876) and *Echinolittorina tuberculata* (Menke, 1828) 0.3%, each. The muricid *Plicopurpura patula* (Linnaeus, 1758) represented 0.6% of the recorded gastropods.

Table 1. Morphometry of the gastropods of Accra beach, island of Barbados. Legend: number of individuals (N), length (L), width (W), height (H), aperture length (Al), aperture width (Aw) and raw data due to the presence of only one specimen (*). Morphometric data: mean±SD (mm).

Specie	N° MZUFRA	N	L	W	H	Al	Aw
<i>Nerita tessellata</i>	Moll 166	212	14.0±2.7	11.6±2.1	7.9±1.4	10.2±2.4	4.7±0.9
<i>N. fulgurans</i>	Moll 167	66	12.6±2.8	10.5±2.0	6.8±1.4	9.2±1.6	4.8±1.1
<i>N. peloronta</i>	Moll 168	16	17.8±4.8	14.4±3.7	9.8±2.5	14.5±3.9	6.7±1.9
<i>N. versicolor</i>	Moll 169	20	14.4±2.1	12.8±2.1	8.4±1.2	11.6±1.8	4.4±0.7
<i>Echinolittorina ziczac</i>	Moll 170	3	10.9±0.9	6.3±0,1	5.7±0.2	5.5±0.4	4.5±0.5
<i>E. angustior</i>	Moll 171	1	8.6*	5.3*	5.0*	4.0*	3.6*
<i>E. tuberculata</i>	Moll 172	1	11.9*	6.52*	5.98*	5.3*	4.59*
<i>Plicopurpura patula</i>	Moll 173	2	34.6±10.8	24.4±9.2	16.7±5.7	27.8±11.0	22.5±8.7

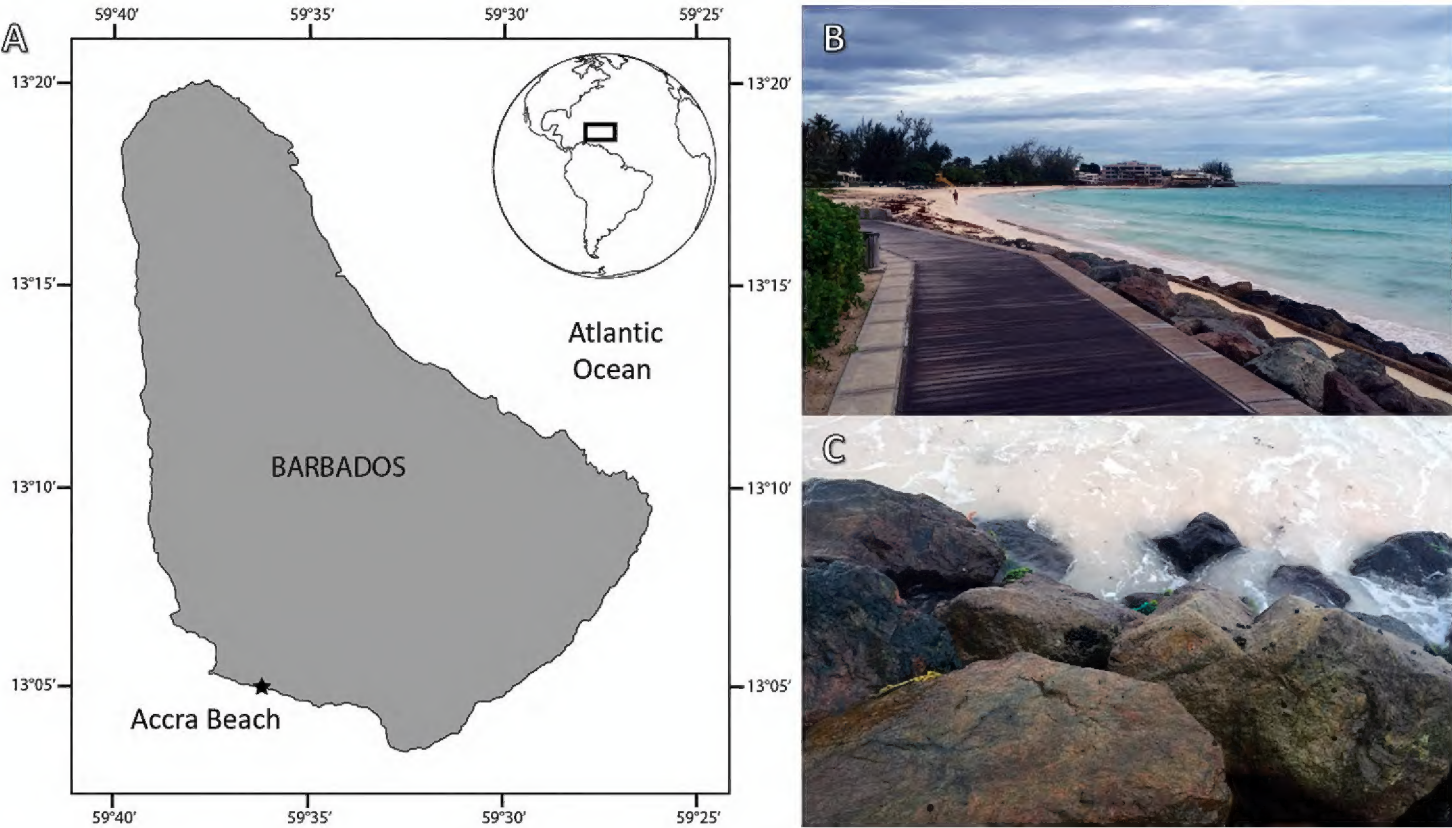


Figure 1. Location of Accra Beach, on the Island of Barbados, Caribbean Sea, North Atlantic Ocean (A). The sampling site in the supralittoral zone presents predominance of large rocks along the beach (B, C).

The taxonomy of the gastropods found is updated according to the *World Register of Marine Species* (WoRMS) available in <http://www.marinespecies.org> (Horton et al. 2019) and the characteristics of the species are described below.

Family Neritidae Rafinesque, 1815
Genus *Nerita* Linnaeus, 1758

***Nerita fulgurans* Gmelin, 1791**
Fig. 2a–c, g–h

Synonymy. *Nerita (Theliostyla) fulgurans* Gmelin, 1791; *Nerita albipunctata* Reeve, 1855; *Nerita antillarum* Gmelin, 1791; *Nerita lindae* Petuch, 1988; *Nerita listeri* Récluz, 1841; *Nerita nigreola* Röding, 1798; *Nerita praecognita* C. B. Adams, 1845.

Characteristics. Predominantly dark color, but with shades ranging from yellow to black. Globular shaped shell with a spiral less than 1/5 of the total length. It has one to three teeth or denticles, four or five narrow spiral ridges and 22 to 30 thick spiral streaks. Yellowish-brown opoosum. Specimens measured between 6.93 mm and 18.03 mm in total length, with the largest record in the literature being 32 mm.

Habitat. Lives on rocks in the intertidal zone, being present in shallow brackish water, near mangroves.

Distribution. East Coast of Florida (EUA), with occurrences in the Gulf of Mexico and Caribbean Sea, to Northeastern Brazil.

References. Reeve (1856), Flores (1964), Matthews-Cascon et al. (1990), Abbott and Morris (1995), Prado (1998), Rosenberg et al. (2009), Rios (2009), Thomé et al. (2010) and Chagas et al. (2016).

***Nerita peloronta* Linnaeus, 1758**

Fig. 2d–f, i–j

Synonymy. *Nerita (Nerita) peloronta* Linnaeus, 1758; *Nerita erythrodon* Récluz, 1850; *Nerita papilio* Röding, 1798; *Nerita sanguidens* Récluz, 1850.

Characteristics. Yellowish coloration with red and black spots. Its shell is elongated globose, showing a concave and oblique spiral at the apex, with thick spiral strands that disappear on the last turn. Suture moderately conspicuous. Operculum pauciespiral, with the presence of a protuberance on the inner border, in orange tones. Outer lip with fine teeth and inner lip with a red blood stain and one to three white teeth. Specimens varying from 8.8 mm to 24.75 mm in total length; the largest record in literature is 49 mm.

Habitat. It lives on rocky substratum in the tidal zone, in shallow water, where there is a small slope. Makes small migrations in search of shelter during the day and food during the night.

Distribution. North Carolina to Florida (USA), with occurrences in the Gulf of Mexico and Caribbean Sea, to North Brazil (state of Pará).

References. Reeve (1856), Flores (1964), Matthews-Cascon et al. (1990), Cervigón et al. (1992), Abbott and Morris (1995), Prado (1998), Leal (2002), Rosenberg et al. (2009) and Chagas et al. (2016).

***Nerita tessellata* Gmelin, 1791**

Fig. 2n–p, s–t

Synonymy. *Nerita (Theliostyla) tessellata* Gmelin, 1791, *Nerita angulata* Röding, 1798, *Nerita exarata* L. Pfeiffer, 1840, *Nerita varia* Mörch, 1852.

Characteristics. Predominantly black coloration, but specimens ranging from black (or gray) to white areas. Its shell is oval, sub-globular, with spira convex strongly spiral. It presents uneven, closed ribs and at the top at an angle. Lips slightly crenulate, columella flattened and concave, with fine granules and arched in the border. It has reduced teeth, usually one to three. Lighter-type operculum, usually

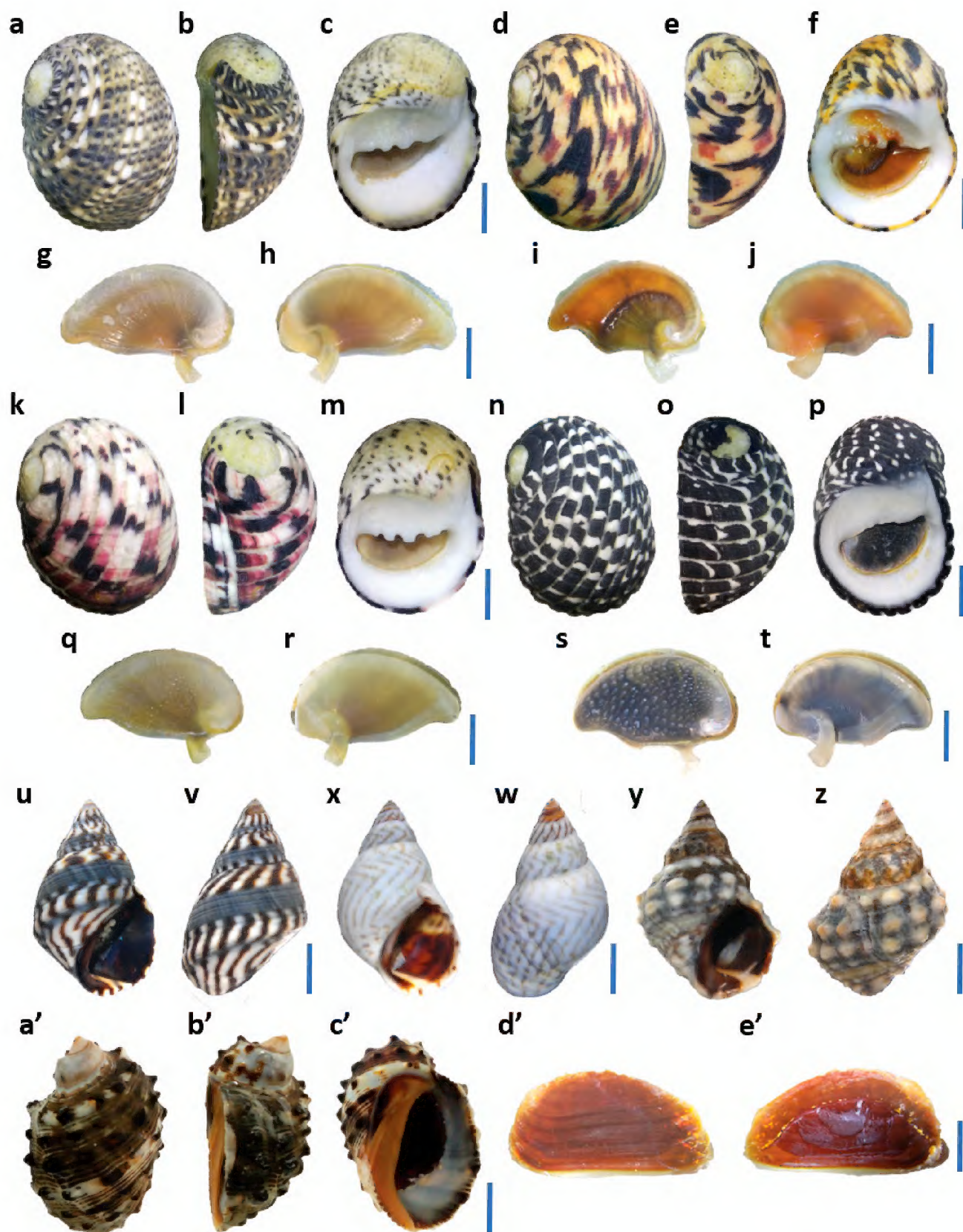


Figure 2. Gastropods sampled on Accra Beach, on the Island of Barbados, Caribbean Sea, North Atlantic Ocean: *Nerita fulgurans* (a–c, g–h), *Nerita peloronta* (d–f, i–j), *Nerita versicolor* (n–p, s–t), *Nerita tessellata* (k–m, q–r), *Echinolittorina angustior* (u–v), *Echinolittorina ziczac* (x–w) and *Echinolittorina tuberculata* (y–z), *Plicopurpura patula* (a'–e'). Scale bars: 3 mm (a–f; k–p; u–v; y–z), 2 mm (x–w), 7 mm (a'–e').

in bluish or yellowish gray. Specimens varied from 8.06 mm to 22.61 mm in total length; the largest record in literature is 25 mm.

Habitat. Inhabits rocky shores.

Distribution. East Coast of Florida, with occurrences in the Gulf of Mexico and Caribbean Sea, to Northeastern Brazil (state of Rio Grande do Norte).

References. Reeve (1856), Flores (1964), Matthews-Cascon et al. (1990), Abbott and Morris (1995), Abbott and Dance (2000) and Rosenberg et al. (2009).

***Nerita versicolor* Gmelin, 1791**

Fig. 2k–m, q–r

Synonymy. *Nerita* (*Nerita*) *versicolor* Gmelin, 1791; *Nerita* (*Ritena*) *versicolor* Gmelin, 1791; *Nerita amplisulcata* Macsotay & Campos, 2001; *Nerita flammea* Gmelin, 1791; *Nerita hertweckorum* Petuch, 1994†; *Nerita musica* Röding, 1798; *Nerita nigrocincta* Nowell-Usticke, 1959; *Nerita pica* Gmelin, 1791; *Nerita selot* Récluz, 1850; *Nerita tricolor* Gmelin, 1791; *Nerita variegata* Mörch, 1852.

Characteristics. Color ranging from black, red, white and yellow. The upper surface of the operculum with a concave parietal zone, totally papillose in the young forms. The convexity of the parietal area is related to the development of the central teeth. In young forms, the four teeth, although conspicuous, are similar in size, thus the convexity of the parietal area is hardly apparent. Sometimes it can have five teeth. Specimens varied from 11.65 mm to 18.35 mm in total length; the largest record in literature is 32 mm.

Habitat. Inhabits the intertidal region, on a rocky substrate, where there is a small slope. Makes small migrations in search of shelter during the day and food during the night.

Distribution. East Coast of Florida (USA), with occurrences in the Gulf of Mexico and Caribbean Sea, to North Brazil (state of Pará).

References. Flores (1964), Chislett (1970), Cervigón et al. (1992), Abbott and Morris (1995), Leal (2002), Rosenberg et al. (2009) and Chagas et al. (2016).

Family Littorinidae Children, 1834**Genus *Echinolittorina* Habe, 1956*****Echinolittorina angustior* (Mörsch, 1876)**

Fig. 2u–v

Synonymy. *Littorina angustior* Mörsch, 1876; *Littorina carinata* d'Orbigny, 1841; *Nodilittorina angustior* (Mörsch, 1876).

Characteristics. It presents conical, sharply pointed shell, predominantly grayish white color with narrow oblique brown lines. The recorded specimen showed 8.64 mm of total length, being the largest record in literature 19 mm.

Habitat. Over (or in crevices) rocky shores.

Distribution. East Coast of Florida (USA), with occurrences in the Gulf of Mexico and Caribbean Sea, Venezuela.

References. Rosenberg et al. (2009) and Reid (2009).

***Echinolittorina ziczac* (Gmelin, 1791)**

Fig. 2 x–w

Synonymy. *Littorina mauritiana* var. *gracilior* Philippi, 1847; *Littorina ziczac* (Gmelin, 1791); *Nodilittorina ziczac* (Gmelin, 1791); *Trochus ziczac* Gmelin, 1791.

Characteristics. Conical, sharply pointed shell, with six to eight turns, the first two being worn. Sculpture of the remainder turns of the shell with 20 to 26 microscopic spiral streaks. It features a pear-shaped shell opening, with two colored bands. The base of the curvature of the columella in shades of dark brown. Shell with coloration in shades of white to bluish gray, presenting irregular stripes in zig-zag in dark brown color. Slightly caressing base and sexual dimorphism. Specimens with a total length varying between 9.93 and 11.56 mm, with the largest record in literature being 29 mm.

Habitat. Inhabits rocky shores in the intertidal zone and on corals.

Distribution. North Carolina to Florida (USA), with occurrences in the Gulf of Mexico and Caribbean Sea, Brazil (entire coast) and Uruguay. Introduced in the Pacific Ocean through the Panama Canal.

References. Abbott and Morris (1995), Abbott and Dance (2000), Rios (2009), Rosenberg et al. (2009), Reid (2009) and Thomé et al. (2010).

Echinolittorina tuberculata (Menke, 1828)

Fig. 2y–z

Synonymy. *Litorina tuberculata* Menke, 1828, *Nodilittorina tuberculata* (Menke, 1828).

Characteristics. Dark brown color. It has a conical shell, with convex loops, ornamented with three spiral cords with whitish nodules. The shell reaches up to 18 mm in total length.

Habitat. It lives in rocky shores and moderately sheltered beaches, in regions above the level of the high tide, sheltering in puddles and/or cracks in the rocks. A specimen with total length of 11.09 mm, the largest record in literature being 23 mm.

Distribution. South Florida, Bermuda, with occurrences in the Gulf of Mexico and Caribbean Sea, to Venezuela.

References. Diaz and Puyana (1994), Abbott and Dance (2000), Reid (2007) and Rosenberg et al. (2009).

Family Muricidae Rafinesque, 1815

Genus *Plicopurpura* Cossmann, 1903

Plicopurpura patula (Linnaeus, 1758)

Fig. 2a'–e'

Synonymy. *Buccinum patulum* Linnaeus, 1758; *Haustrum tuberculatum* Perry, 1811; *Purpura patula* (Linnaeus, 1758).

Characteristics. It features six or seven spiral strings adorned with sharp nodules. Dark gray color with the opening of the columella ranging from orange to pink salmon. Specimens between 27.01 mm and 42.22 mm of total length, the largest recorded in literature being 100 mm.

Habitat. Inhabits intertidal zone on rocky shores.

Distribution. South Florida, Bermuda, with occurrences in the Gulf of Mexico and Caribbean Sea, to Venezuela.

References. Diaz and Puyana (1994), García-Ibáñez et al. (2007) and (Rosenberg et al. 2009).

The knowledge about the diversity of gastropods in the Caribbean region, even with ecological data gaps, is well documented. According to the Malacolog Platforms Version 4.1.1 – The Database of Western Atlantic Marine Mollusca (available at <http://www.malacolog.org>) (Rosenberg 2009), there are currently 387 shellfish records for the island of Barbados. However, among the gastropods found in the present study, *N. fulgurans* and *E. angustior* species were not yet recorded for the region, according to the mentioned platform. The absence of these two species may be related to the systematics of both genera in the West, which has been controversial due to intraspecific variability and similar characters of their shells and radula, and also for the lack of anatomical descriptions (Reid 2007, 2009).

The Neritidae family has an almost global distribution. However, it occurs mainly in the range that covers tropical-temperate regions (Russel 1941; Quintero-Galvis and Castro 2013), with species occurring in marine, brackish and freshwater environments (Tan and Clements 2008). The neritids are of little economic importance (Russel 1941), however, there are records of the use of species in the making of zooartesanato in the Amazon region (Barros and Chagas 2019). Nevertheless, there is a record of riverside dwellers on Marajó Island, northern region of Brazil, using *Neritina zebra* (Bruguière, 1792) in their diet, which presents edible meat yield of more than 35% as food source (Barros et al. 2017).

The coloration of the neritid gastropods, as in many other groups of animals, presents little specificity, being extremely variable, which constitutes one of the explanations for their extensive synonymy (Russel 1941). However, in order to correct taxonomic identification, in addition to the coloration, the morphological characteristics of the shells of the neritids are indispensable (Flores 1964; Prado 1998; Tan and Clements 2008; Chagas et al. 2016), such as the number of spiral ridges (Flores 1964).

Chislett (1970), in a comparative study of the ecological aspects of *N. peloronta*, *N. versicolor* and *N. tessellata*, collected in three distinct regions of Barbados Island (Little Bay, Harrison Lighthouse and South Point), found that the local neritids reproduce throughout the year, showing no significant variations in growth rates. This corroborates the fact that representatives of this family were the most abundant during the collection at the beach of Accra.

Another feature that may contribute to the abundance of neritids is their ability to store water within their shells, making them withstand long periods of desiccation, and allowing their constant presence in intertidal areas and rocky shores (Prado 1998).

Gastropods of the Littorinidae family are among the most studied marine taxa and their systematics has been the subject of much research (Reid and Williams 2004). Littorinids of the genus *Echinolittorina*, evidenced during the collections, have global distribution, generally inhabiting rocky shores (Reid 2007, 2009), which

is in accordance with the environment observed in the beach of Accra. In addition to detailed descriptions of shell morphological characters (ornamentation, operculum, staining) and internal anatomy (sperm, egg and radium capsules, among others), several articles have recently analyzed the phylogeny of littorinids (Janson 1982; Reid and Williams 2004; Reid 2007, 2009; Diaz-Ferguson et al. 2011; Barboza et al. 2012).

Gastropods of the family Muricidae are among the most notable and well-known among the large and taxonomically important mollusks, especially those of the subfamily Rapaninae (Claremont et al. 2013). Muricides are active predators that play an important ecological role in structuring coastal communities (Vermeij and Carlson 2000).

The gastropod *P. patula* has a hypobranchial gland that secretes a sulphide that acquires a purple coloration in the presence of oxygen and sunlight (García-Ibáñez et al. 2007; Chenoweth 2011). Chenoweth (2011) points out that *P. patula* is not an edible species, but there is evidence of the probable use of this gastropod by ancient people to dye materials (e.g., textiles and ceramics) and make decorative utensils with shell. Although this species is not the most abundant of Barbados Island, as indicated by the low abundance of individuals in the collection, its aggregate behavior is considered one of the factors that contribute to the dominance of species in other regions (García-Ibáñez et al. 2007).

The biodiversity of the Caribbean is studied worldwide, especially with respect to aquatic diversity, including fishes of economic importance and invertebrates. The present study represents a contribution to the knowledge of the biodiversity of gastropod mollusks to Barbados Island and highlights the need for new studies on the ecology and spatial distribution of the benthic fauna throughout the region.

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